Research Report 1267

LEVEL II

(14)

ANALYSIS OF THE THREAT ORIENTED MARKSMANSHIP TRAINING CAPABILITIES OF THE INFANTRY REMOTED TARGET SYSTEM (IRETS)

AD A109468

Ronald D. Klein and Jeffery L. Maxey
Defense Sciences Laboratories
Litton-Mellonics Systems Development Division

ARI FIELD UNIT AT FORT BENNING, GEORGIA

U. S. Army

Research Institute for the Behavioral and Social Sciences

September 1980

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NOTICES

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Research Report 1267	2. GOVT ACCESSION NO. AD-A109 458	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Analysis of the Threat Oriented Marksmanship Training Capabilities of the Infantry Remoted Target System (IRETS)		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Ronald D. Klein Jeffery L. Maxey		8. CONTRACT OR GRANT NUMBER(s) DAHC 19-77-C-0011
9. PERFORMING ORGANIZATION NAME AND ADDRESS Litton-Mellonics Systems Development Division Defense Sciences Laboratories P. O. Box 2498 Fort Benning, GA 31905		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q763743A773
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Research Institute for the Behavioral and Social Sciences PERI-IJ Fort Benning, GA 31905		12. REPORT DATE September 1980 13. NUMBER OF PAGES 32
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Combat Referencing
Infantry Remoted Target System
IRETS
M16A1 Rifle
M16A1 Rifle Marksmanship
Marksmanship Training
Measures of Performance
Moving Targets
Rifle Marksmanship Training
Rifle Ranges
Threat Oriented Training
TRAINFIRE

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

At present in the U. S. Army, rifle marksmanship training is conducted on TRAINFIRE ranges which were developed and installed during the late 1950's at selected Army Training Centers and other major U. S. Army installations. These ranges are rapidly becoming obsolete. Most are maintenance liabilities and are not cost effective because of excessive ~~repair and~~ lost training time. Further, the control systems for these ranges are antiquated. (continued)

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As a consequence, the U. S. Army is considering the procurement of a new, improved live fire training system, the Infantry Remoted Target System (IRETS). This system has been designed to provide for the conduct of rifle marksmanship training in a threat oriented context. Early in 1976 the U. S. Army Infantry Center (USAIC) published threat oriented rifle marksmanship scenarios for the defense, the attack, and the counterattack. The USAIC defense scenario was subsequently incorporated into the IRETS specifications. In this regard, the defense scenario and its target presentation requirements served as the basis for the target conditions to be portrayed by and the live fire range requirements for the IRETS.

Because it is planned to replace selected rifle marksmanship live fire ranges with the IRETS, it is important to know to what extent the planned capabilities of the IRETS are consistent with current concepts of threat oriented rifle marksmanship training. This report presents the findings of a comparative analysis of the specifications for the IRETS and the target presentation and training requirements for threat oriented rifle marksmanship training.

The purpose of the analysis was to identify potential shortcomings in the threat oriented training capabilities of the IRETS. Where shortcomings were found to exist, possible means of resolving these were identified. For this reason, the findings of this report are supplemented with recommendations for resolving identified shortcomings in the threat oriented training capabilities of the IRETS.

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Ronald D. Klein and Jeffery L. Maxey
Defense Sciences Laboratories
Litton-Mellonics Systems Development Division

Submitted by:
H. C. Strasel, Chief
ARI FIELD UNIT AT FORT BENNING, GEORGIA

Approved by:

E. Ralph Dusek, Director
PERSONNEL AND TRAINING RESEARCH LABORATORY

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333

Office, Deputy Chief of Staff for Personnel
Department of the Army

September 1980

Army Project Number
2Q763743A773

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FOREWORD

This report is provided by the Mellonics Systems Development Division of Litton Systems, Inc., to the Army Research Institute for the Behavioral and Social Sciences (ARI) under Contract Number DAHC 19-77-C-0011. Under the contract, a part of Mellonics' effort concerns support to the Training Effectiveness Analysis (TEA) research presently being conducted by the ARI for the United States Infantry School (USAIS). One portion of this research involves the analysis of the effectiveness of training for rifle marksmanship skills in a threat oriented context. Because there are tentative plans to replace selected rifle marksmanship live fire ranges with the Infantry Remoted Target System (IRETS), it is important to know to what extent the planned capabilities of the IRETS are consistent with current concepts of threat oriented rifle marksmanship training. This report presents the findings of a comparative analysis of the specifications for the IRETS and the target presentation and training requirements for threat oriented marksmanship training. Additionally, the findings of this report are supplemented with recommendations for resolving identified shortcomings in the IRETS capability to provide for the conduct of training in a threat oriented context.

The research was coordinated with the United States Army Infantry School which is the proponent agency for M16A1 rifle marksmanship training program development.

ARI research in marksmanship training systems development is conducted as an inhouse effort augmented by contracts with organizations selected as having unique capabilities for research in the area. The project was conducted as part of ARMY RDTE Project 2Q763743A773, FY 78 Work Program, and RDTE Project 2Q263743A773, FY 79. It was directly responsive to the requirements of FORSCOM, USAIS and TRADOC.

Joseph Zeidner

JOSEPH ZEIDNER
Technical Director

BRIEF

Requirement:

To determine if the planned capabilities of the Infantry Remoted Target System (IRETS) are consistent with current concepts of threat oriented rifle marksmanship training and to provide recommendation for resolving any identified shortcomings in the capability of the IRETS to provide realistic training in a threat oriented context.

Procedure:

The potential shortcomings in the threat oriented marksmanship capabilities of the IRETS were identified from a comparison of the contract for the IRETS and the target presentation that Infantryman are expected to face on the modern battlefield.

Findings:

Target spacing on the IRETS range is inadequate. The target separation distances planned for the IRETS are too large. The distribution of target engagements as a function on target-to-firer range planned for the IRETS is at variance with the distribution appropriate for representing the combat threat. Deviations were found to exist between the target exposure times planned for use in the IRETS defense scenario and those recommended for use in small arms training facilities. The IRETS as currently configured does not permit an individual to train as a part of a fire team or other small unit. The IRETS range data collection capabilities do not provide a means for collecting diagnostic measures of performance relative to the use of appropriate target lead, sighting technique, and firing technique. The moving target "running distances" are too short to realistically represent the fire and movement tactics of threat personnel targets. The hit sensing subsystems of the IRETS should be able to score multiple hits when live firing is conducted in the automatic mode. The data collection and target control components of the IRETS are not interconnected. For this reason, the IRETS has no capability for making a "dynamic" response to the level of fire generated by the trainee. As currently designed, the IRETS has no malfunction feedback circuit for the hit sensing subsystem. As it now exists, the IRETS has no capability to provide time based measures of firing performance. This limits the diagnostic capabilities of the system.

Utilization of Findings:

The information in this document is applicable in particular to the proponent of the IRETS and in general to all developers of combat firing ranges or supporting literature.

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ANALYSIS OF THE THREAT ORIENTED MARKSMANSHIP TRAINING CAPABILITIES OF THE INFANTRY REMOTED TARGET SYSTEM (IRETS)

INTRODUCTION

At present in the U. S. Army, rifle marksmanship training is conducted on TRAINFIRE ranges which were developed and installed during the late 1950's at selected Army Training Centers and other major U. S. Army installations. These ranges are rapidly becoming obsolete. Most are maintenance liabilities and are not cost effective because of excessive repair expenditures and lost training time. Further, the control systems for these ranges are antiquated.[1]

As a consequence, the U. S. Army is considering the procurement of a new, improved live fire training system, the Infantry Remoted Target System (IRETS). This system has been designed to provide for the conduct of rifle marksmanship training in a threat oriented context. It is now under development at Fort Benning, Georgia and will be tested by the U. S. Army Infantry Board (USAIB) during the Spring of 1978.

Early in 1976 the U. S. Army Infantry Center (USAIC) published threat oriented rifle marksmanship scenarios for the defense, the attack, and the counterattack.[2] The USAIC defense scenario was subsequently incorporated into the IRETS specifications. In this regard, the defense scenario and its target presentation requirements served as the basis for the target conditions to be portrayed by and the live fire range requirements for the IRETS.

The Mellonics Systems Development Division of Litton Systems, Inc., under contract to the U. S. Army Research Institute (ARI), is supporting the Training Effectiveness Analysis (TEA) research currently being conducted at the Fort Benning ARI Field Unit. One portion of this research involves the analysis of the effectiveness of training for rifle marksmanship skills in a threat oriented context. Because it is planned to replace selected rifle marksmanship live fire ranges with the IRETS, it is important to know to what extent the planned capabilities of the IRETS are consistent with current concepts of threat oriented rifle marksmanship training. This report presents the findings of a comparative analysis of the specifications for the IRETS and the target presentation and training requirements for threat oriented rifle marksmanship training.

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[1] Department of the Army, Training Device Requirement (TDR) for the Infantry Remoted Target System (IRETS). Fort Eustis, VA: U. S. Army Training Support Center, July 1977.

[2] Jehan, H. Threat oriented evaluation: A new approach to training with applications to rifle marksmanship training (Draft). Fort Benning, GA: U. S. Army Infantry Center, February 1976.

The purpose of the analysis was to identify potential shortcomings in the threat oriented training capabilities of the IRETS. Where shortcomings were found to exist, possible means of resolving these were identified. For this reason, the findings of this report are supplemented with recommendations for resolving identified shortcomings in the threat oriented training capabilities of the IRETS.

OBJECTIVES

The objectives of this research were:

- To identify potential shortcomings in the threat oriented training capabilities of the IRETS.
- To identify and recommend means for resolving identified shortcomings in the threat oriented training capabilities of the IRETS.

METHOD

The potential shortcomings in the threat oriented marksmanship capabilities of the IRETS were identified from a comparison of the contract specifications for the IRETS[3] and the target presentation requirements of the USAIC defense scenario, as well as the requirements for conducting threat oriented training as outlined by Klein and Tierney[4] and Rosen and Behringer.[5]

In addition, a visit was made to the manufacturing plant of the IRETS prime contractor. At the prime contractor's manufacturing plant, prototype equipment components for the IRETS were examined and detailed discussions were conducted concerning the anticipated performance of the system. As appropriate, the information derived from this visit was incorporated into the analysis of the system.

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3 Naval Training Equipment Center, Specification for Infantry Remoted Target System (IRETS). Orlando, FL: Author, May 1976.

4 Klein, R. and Tierney, T. Analysis of factors affecting the development of threat oriented small arms training facilities (Task Report). Fort Benning, GA: Mellonics Systems Development Division, Litton Systems, Inc., August 1977.

5 Rosen, M. and Behringer, R. M16 rifle marksmanship training development (Final Report). Springfield, VA: Mellonics Systems Development Division, Litton Systems, Inc., 1977.

Based on the results of the IRETS analysis, shortcomings in the threat oriented training capabilities of the system were identified. Next, means for reducing or eliminating the impact of identified shortcomings were developed. In those cases for which no simple solutions could be identified, the shortcomings were highlighted so that an examination of these could be conducted during acceptance and operational testing for the IRETS.

FINDINGS

In this section of the report the findings resulting from the comparative analysis of the IRETS specifications and the target presentation and training requirements for threat oriented rifle marksmanship training are presented. These findings are presented in terms of the following:

- IRETS representation of the threat,
- Potential hardware system shortcomings,
- Potential software system shortcomings.

IRETS REPRESENTATION OF THE THREAT

According to Jehan[6] the threat on the modern battlefield that can be countered by the rifleman is an enemy soldier armed with his weapon system. Obviously, the exact nature of this enemy soldier/weapon system combination will depend on the type of enemy force encountered at the time of battle and the nature of the battlefield situation, i.e., a dismounted light infantry attack, a dismounted light infantry defense, a mechanized infantry attack with supporting armor, or an armor attack, to name a few possible situations.

For the purpose of rifle marksmanship training, however, the standard approach has been to limit the enemy soldier/weapon system combination to a soldier armed with his individual weapon, usually a rifle. Further, for the purposes of this training, the battlefield situation has been limited to either a defensive or offensive context involving only the dismounted light infantry component of an enemy force less its mortar and grenade launching capabilities.

Given the above limitations, it is clear for training purposes that the rifle defeatable threat is represented by collections of personnel targets, both moving and stationary, situated in a field environment. As currently developed, the IRETS has been designed to portray a collection of dismounted, light infantry soldiers attacking a friendly defensive position.

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6 Jehan, H., op. cit.

In this section of the report, the adequacy with which the IRETS portrays this threat is discussed. The specific factors addressed in this discussion include the following:

- o Target separation on the IRETS range,
- o Target-to-firer distances represented on the IRETS range,
- o Target presentation frequency,
- o Target exposure times,
- o Employment of battlefield noises,
- o Employment of limited visibility conditions,

In addition to the above factors, this section of the report presents a discussion of selected aspects of training as they relate to the conduct of threat oriented rifle marksmanship training. These include:

- o Firing positions appropriate for trainee use during live firing,
- o Night training considerations,
- o Squad member live firing interactions,
- o Diagnostic data collection during live fire training.

Target Separation on the IRETS Range. Analyses of threat tactics[7,8] suggest that an enemy unit advancing on a friendly position is likely to move in short rushes. These will vary in length from 15 to 20 meters. The proposed range design for the IRETS calls for positioning stationary targets at 25, 50, 100, 150, 200, 250, and 300 meter target-to-firer distances. The design also calls for interspersing moving targets among the stationary targets at target-to-firer distances of 15, 35, 75, 125, and 185 meters. For just stationary targets, the between-target separation is for the most part 50 meters. Considering both stationary and moving

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7 Klein, R. and Tierney, T., op. cit.

8 Rosen, M. and Behringer, R., op. cit.

targets yields between-target distances of 50 meters in the 200-300 meter range band and average distances of 25 meters in the 0-200 meter range band. It is thus evident that the separation distances planned for the IRETS range are in excess of that expected from analyses of threat movement tactics. For this reason, it must be expected that this discrepancy may contribute to a less than realistic simulation of a threat attack. Therefore, it may be appropriate to consider adding additional stationary targets or moving selected targets closer together so that smaller apparent rush distances are achieved.

Target-to-Firer Distances Represented on the IRETS Range. Analyses of combat data suggest that the closer target-to-firer distances should be emphasized in establishing the frequencies with which targets are presented during a live fire exercise. Most of the target mechanisms should be located within 150 meters of the firer. Nearer targets should appear more frequently than targets presented farther away. Based on evidence from combat films, Klein and Tierney suggest that at least 50 per cent of the targets should be in the 50-100 meter range, 10 per cent closer, 30 per cent scattered between 100 and 200 meters, and the final 10 per cent between 200 and 300 meters.[9]

Table 1 presents a comparison of the distribution of target presentations by target range for the IRETS defense scenario and the distribution recommended by Klein and Tierney.[10] This table shows that significant discrepancies exist between the IRETS scenario and the recommended target presentation distribution for all but the 200-300 meter range band. Thus, it is clear that the distribution of target engagements planned for the IRETS is at variance with the Klein and Tierney recommendation. Obviously, to make the IRETS scenario more realistic, it may be necessary to adjust the frequency with which targets are presented within each range band so that a decided majority of the target presentations occur at nearer target-to-firer ranges.

Target Presentation Frequency. Jehan[11] reports that current Soviet military doctrine calls for a force ratio of 6 to 1 for instigating a major attack against U. S. forces. Jehan further reports that if the enemy is repelled after an attack, then the retreating force would probably represent a force ratio of 3 to 1. Under the above conditions, Jehan concludes from an analysis of field experimentation data that a total of 33 target presentations are required to represent a threat attack, while 17 target presentations are required to represent a threat retreat on a live fire range. Thus, for a complete attack-retreat scenario, a total of 50 target presentations would be required for each lane of a live fire range.

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9 Klein, R. and Tierney, T., *op. cit.*

10 Klein, R. and Tierney, T., *ibid.*

11 Jehan, H., *op. cit.*

Table 1

COMPARISON OF THE TARGET PRESENTATION DISTRIBUTIONS FOR THE IRETS DEFENSE SCENARIO AND THE DISTRIBUTION OF TARGET PRESENTATIONS RECOMMENDED BY KLEIN AND TIERNEY

	Percent of Targets in Each Range Band	
Target Range Band	IRETS Target Presentation Distribution	Klein and Tierney Target Presentation Distribution
0 - 50 meters	22%	10%
50 - 100 meters	24%	50%
100 - 200 meters	42%	30%
200 - 300 meters	12%	10%

Rosen and Behringer[12] indicate that a 3 to 1 force ratio is most likely to characterize the modern battlefield. This is because attacking threat platoons normally operate across a 200 meter front, while U. S. squads usually defend across a 100-125 meter front. Further, it may be reasonable to assume that a threat force would only retreat when the force ratio had been reduced to unity, e.g., 1:1. Under these conditions, considerably fewer target presentations would be required to represent a threat attack followed by a retreat of threat forces. In particular using the procedure employed by Jehan[13], the target presentations required to represent a threat attack would be 17 presentations, while the target presentations required to represent the retreat would be six presentations. Thus, under the above conditions, a total of 23 presentations would be adequate for an attack-retreat scenario for each lane of a live fire range.

The IRETS defense scenario was adapted directly from the recommendations presented by Jehan. For this reason, a total of 33 target presentations occur during the attack phase of the scenario, while a total of 17 presentations occur during the retreat phase. In this respect, the IRETS defense scenario is a direct representation of the threat as conceived by Jehan. If, however, the Rosen and Behringer force ratios are assumed for the attack and the retreat, then fewer target presentations could be employed for the IRETS defense scenario. Thus, it would be appropriate for military experts to consider this issue and decide which of the two sets of circumstances (or others) are appropriate representations of what the infantryman is likely to experience on the modern battlefield. Based on their decision, the appropriate number of target presentations for the IRETS could then be firmly established.

Target Exposure Times. Klein and Tierney[14] have found from analyses of combat data and the results of field studies that personnel targets keep exposure time to a minimum and make frequent use of cover and concealment tactics. As a consequence, they find that hit probabilities in combat and combat-like situations are generally quite low, e.g., not greater than about .25. The implication of this result is that if completely realistic target situations are employed during training, then it is likely that trainees will hit targets in these situations so infrequently as to learn little about the appropriate techniques for using the rifle in combat. For this reason, Klein and Tierney recommend

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12 Rosen, M. and Behringer, R., op. cit.

13 Jehan, H., op. cit.

14 Klein, R. and Tierney, T., op. cit.

that target exposure times during the initial stages of training should be lengthy. As training progresses, these times should be reduced. Further, these scientists recommend that target exposure times should vary from 2 to 8 seconds at the nearer distances (100 meters or less) and 4 to 12 seconds at the longer distances (over 100 meters) on training ranges.

Table 2 presents the target exposure times employed during the attack and retreat phases of the IRETS defense scenario for both stationary and moving targets. In terms of the guidelines proposed by Klein and Tierney, five instances occur in which deviations exist. These are as follows:

- o For the attack phase, a 25-meter stationary target is presented for 9 seconds, one second in excess of the maximum suggested for 100-meter (or less) targets.

- o For the attack phase, a 200-meter stationary target is presented for only one second, three seconds less than the minimum suggested for targets located at distances in excess of 100 meters.

- o For the retreat phase, a 25-meter and a 100-meter stationary target are each presented for 9 seconds, one second in excess of the maximum suggested for 100-meter (or less) targets.

- o For the retreat phase, a 125-meter moving target is presented for only two seconds, two seconds less than the minimum suggested for targets located at distances in excess of 100 meters.

In summarizing the above deviations, two of these involve target exposure times that are less than the minimum time recommended by Klein and Tierney, while the remaining three involve exposure times in excess of the maximum recommended time. In judging the impact of these deviations, target presentations involving less than the recommended exposure time will probably have more of a negative effect on the trainee's firing proficiency than target presentations involving more than the recommended exposure time. This is because short duration targets are less likely to be seen, more difficult to sight on, and less likely to be hit than are long duration targets. For this reason, the exposure time of targets currently presented for time intervals shorter than the recommended interval should be increased at least to the minimum recommended interval.

Finally, for the targets that are currently exposed for times in excess of the maximum recommended interval, it is likely (as implied above) that these targets do not constitute a real problem, particularly since the deviation in these cases is only one second. Therefore, unless a change in these times can be accomplished without great difficulty, there is no real reason to resolve these deviations.

Table 2

TARGET EXPOSURE TIMES EMPLOYED DURING THE ATTACK AND RETREAT PHASES OF THE IRETS DEFENSE SCENARIO

			Exposure Times (sec.)											
Phase	Target Type	Target Range	1	2	3	4	5	6	7	8	9	10	11	12
Attack	Stationary	25								X	X			
		50		X				X	X					
		100				X				X				
		150							X					
		200	X							X			X	
		250							X			X		
		300								X	X			
	Moving	15			X									
		35		X		X								
		75						X						
		125			X		X							
		185				X	X	X						
Retreat	Stationary	25						X			X			
		50								X				
		100									X			
		150						X				X		
		200							X	X				
		250							X					
		300							X					
	Moving	35		X										
		75					X							
		125		X										
		185				X	X							

Employment of Battlefield Noises. Rosen and Behringer[15] suggest that a need exists to provide distractions in the form of battlefield noises near the firer to enhance realism in the marksmanship training environment. In the past, mortar and artillery simulators have been effectively employed to provide such distractions. These influences, however, are not part of the IRETS. Therefore, some consideration should be given to the possibility of adding distractions in the form of battlefield noises to the IRETS in order to enhance its operational realism. In this regard, it might be appropriate to consider conducting a study of the influence of battlefield distractions during the operational testing of the IRETS. From such a study it would be possible to determine if the potential benefits of such distractions are cost effective.

Employment of Limited Visibility Conditions. During combat it is not uncommon for daylight visibilities to be limited by dust, haze, and smoke. Inclusion of these conditions during use of the IRETS might reduce the degree of environmental sterility that is typical of live fire ranges. As currently designed, the IRETS has no capability for producing the limited visibilities created by dust, haze, and smoke. This, however, could be accomplished in at least two ways:

- Small smoke generators or trailer mounted dust bowls actuated by blasts of compressed air could be positioned on the training facility to take advantage of prevailing winds.

- Smoke could be pumped through a perforated pipe located across the range, 10 to 15 meters in front of the trainee firing positions.

Such possibilities should be considered during subsequent refinements of the IRETS. If the addition of a means to create limited daylight visibility conditions is determined to be feasible and practical, it would be appropriate to study the effect of such conditions on rifle marksmanship training. In this way, the actual benefits accruing from this training condition could be determined.

Firing Positions Appropriate for Trainee Use During Live Firing. Current U. S. Army doctrine[16] emphasizes the use of the parapet foxhole as the prime fighting position for combat. When it is not possible to construct such a position, this doctrine stresses the use of sites that provide natural cover and concealment. In these cases, the prone firing position is emphasized.

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15 Rosen, M. and Behringer, R., *op. cit.*

16 Department of the Army, *Infantry fighting positions* (TRADOC Bulletin No. 9). Fort Monroe, VA: U. S. Army Training and Doctrine Command, September 1977.

As presently configured, the IRETS range provides for firing from the foxhole and prone positions. This is obviously consistent with current Army doctrine. From analysis of combat data, Klein and Tierney[17] have discovered, however, that in past conflicts U. S. soldiers used these positions less than 20 per cent of the time. Their analysis showed that the kneeling and standing firing positions were the dominant positions used during combat. These results imply that consideration should be given to providing firing positions on the IRETS range that will allow for trainees to fire from defensive kneeling and standing firing sites. In this regard, such positions could be made available by constructing window casements, log fences, or brick walls with appropriate openings at the firer's position on the IRETS firing lanes. In this way, it would be possible for trainees to have an opportunity to engage targets not only from foxhole and prone firing positions, but also from kneeling and standing supported positions that provide some cover and concealment.

Night Training Considerations. It is planned to use the IRETS for both day and night training. In the night mode targets located at target-to-firer distances in excess of 150 meters are not employed. The assault scenario for the night mode calls for a total of 30 target presentations. This includes both moving and stationary targets. Some of the targets, when activated, produce a muzzle flash. Selected targets are also illuminated with overhead flares.

A potential problem with using the IRETS range for night target engagement involves the target-to-firer distances that will be played during the night assault scenario. In this regard, current night firing experience on the USAIB facilities suggests that targets located at ranges in excess of 60 meters are not engagable even with use of flash simulators. Therefore, it is appropriate to determine through testing to what extent target hits are achievable at the long target ranges during the night use of the system. If it is found that little value accrues from use of the long target ranges, then it may be appropriate to consider revising the night scenario to reflect such findings.

Squad Member Live Firing Interactions. The rifleman performs on the battlefield as a member of a team. At some point in the training process, the soldier must learn to fire his weapon as a part of a team. This entails learning fire coordination, use of overlapping fires, and techniques of fire distribution.

The current IRETS range consists of non-overlapping areas of responsibility in which the control of fires are assumed by range cadre. Further, the extreme separation of adjacent lanes (30 meters) prohibits the use of this facility for training squads of soldiers to operate as a team. Thus, the flexibility of the system is limited.

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17 Klein, R. and Tierney, T., op. cit.

Possibly this potential problem can be handled through use of the portable IRETS equipment. This should be investigated during the operational testing of the system. In this way, the possibility of increasing the flexibility of the IRETS can be determined.

<u>Diagnostic Data Collection During Live Fire Training</u>. Rosen and Behringer[18] have expressed concern that current rifle marksmanship training does not provide for the proper diagnosis of poor firing techniques. The IRETS, as currently conceived, does not relieve this concern. The only measure of performance (MOP) generated by the IRETS is the number of hits achieved during live firing. This MOP only provides a gross measure of the firer's ability to consistently engage targets. It provides no information about the following aspects of firing:

- The extent to which the appropriate lead is applied to moving targets.
- The nature of errors in applying lead to moving targets.
- The extent to which the firer tends to flinch when firing.
- The extent to which the firer employs improper trigger control when firing.
- The nature of sight alignment errors.
- The extent to which the firer uses an improper breathing technique when firing.

Concern over these aspects of the firer's performance of course assumes that the IRETS range is the appropriate place for isolating problems in firing technique. It is likely, however, that if these aspects of the firer's performance are not addressed at this point in training, they will not be addressed at all. This is because the training that will occur using the IRETS represents one of the few times in the soldier's training cycle where he will be intensively observed and measured. For this reason, it is appropriate to consider intensively measuring the soldier's firing technique in the context of the IRETS.

There are several ways in which this could be accomplished. First, it may be possible to add diagnostic measuring devices to the IRETS which function in a variance reporting mode. Under these conditions, as long as the trainee does not deviate from a selected performance level, no measurements are taken. When an error condition or a particular firing problem occurs, a signal light is activated to alert the instructor that

18 Rosen, M. and Behringer, R., *op. cit*.

the trainee should be observed closely because he is making errors or having problems that are acting to degrade his performance.

Second, instrumentation located near each firing position could be employed to monitor the firer's response time and his rate of fire. Soldiers who fire too rapidly or too slowly may be having trigger control or sight alignment problems. Early identification of these problems based on data from the instrumentation at the firing position would allow instructors to work with the soldiers and correct the problem.

Finally, pairs of shock wave sensors could be located near selected IRETS targets, both moving and stationary. Data generated by these sensors would identify firings that are consistently off to one side of the target or the other for stationary targets. For moving targets, pairs of these sensors could be used to identify when the firer under - or - over leads the target. Once the nature of the error is known, instructors can then work with the trainee to eliminate the problem.

POTENTIAL HARDWARE SHORTCOMINGS

This section presents potential hardware shortcomings and addresses the following areas:

- Moving target subsystem
- Hit sensing subsystem
- Sound simulator subsystem
- Data collection and target interface
- Hardware add-on capability
- IRETS Control Console operation
- Malfunction feedback circuits

Moving Target Subsystem. There are four operating characteristics that should be examined with reference to the moving target subsystem: Hit scoring, target body presentation angle, duration of target exposure, and the chain drive for the moving target. The IRETS specifications[19] state that a range control console will record and produce a hard copy output of the total moving target hits for each firing lane. Moving target hits are also to be recorded on the target lifting device. Since the moving target carrier uses a trailing wire to carry the hit signal to

19 Department of the Army, July 1977, op. cit.

the range control console, the wire is subject to: (1) abrasion if it is dragged along the ground, (2) severing by projectiles if it is suspended above the ground, or (3) cracking if it is repeatedly wound in and out on a reel attached to the carrier track. The USAIB should be made aware of these potential problems, since they could limit the reliability of the moving target subsystem.

Another problem in this area concerns the length of time moving targets are exposed. The USAIC defense scenario recommends exposure times up to six seconds for moving targets. Since the moving target tracks of the IRETS are only 10 meters long, a moving target traveling approximately 8 mph (the expected speed of a combat soldier advancing from position to position) will have a maximum exposure time of less than three seconds. The only way in which longer exposure times can be achieved at this speed is to conduct the presentation in two stages: stationary, for up to three seconds; and then moving the maximum length of the track. This type of presentation permits the required six second exposure time, but it detracts from the IRET's realism. The moving target is probably the most expensive part of the IRETS. To use it as a stationary target, even for a limited time, may not be cost effective. To realize the full value of the investment, the moving target subsystem should add to the realistic threat presentation. For the reasons discussed above, the current configuration of the moving target subsystem may fail to fulfill its intended role. To compensate, target speeds could be lowered. This, however, subtracts from the desired realism. Further, since speeds cannot be changed during a particular sequence, all target presentations (even two second exposures) would have the same reduced target speed. Thus, it may be appropriate to increase the track length of moving targets so that the maximum exposure times of the USAIS scenario can be achieved.

The final area of concern, with respect to moving targets in the IRETS, is the chain drive. Two potential problems are wear (due to oxidation and weathering) and stoppages (due to picking up loose twigs blown into the drive by wind). During acceptance testing an assessment should be made to determine if these potential problems occur and with what frequency.

Hit Sensing Subsystem. The current hit sensor is a piezoelectric sensor mounted at the base of the target which senses the "thumps" of the projectile as it hits the target. The sound moves through the target body to the base of the target. According to contractor tests, the signal is seriously attenuated as it passes through severe curves in the molded body. Hits in the target's head area seem to create the largest problem, especially with the caliber .22 long rifle projectile. Sensor output could be amplified to increase the signal to noise ratio thus improving sensitivity. This action, however, would also increase the sensor's sensitivity to extraneous noises caused by the vibrations, debris, and shockwaves from near misses. There is also the related problem of a deteriorated sound carrying capability after the target

has been perforated by many hits. These potential problem areas should be thoroughly examined during acceptance testing.

Another area of concern is the location of the associated signal conditioning electronic package. If located on the target, it is subject to the extreme heat, cold, and rain of the various seasons. It is also subject to rough handling, as malfunctioning components are replaced on the training facility. Further, a power supply is required at the target. Its primary advantage is in the strength of the signal (signal to noise ratio) that is sent to the recording console. The contractor should be aware of the difficulties in the operating environment that must be overcome. Testing should also focus on this potential problem area.

The IRETS specifications[20] state that the IRETS equipment must operate at 95% humidity. This can be interpreted as not being required to operate while raining. Summer in the Southeast, however, is typified by afternoon thunder showers which can come and go rather quickly. Although the humidity reaches 100% in the immediate area of the storm, it can drop quickly as the storm moves away. If after being soaked, a sustained dry-out period is required, a significant amount of training time can be lost, even though a storm of very short duration passes through the area. Usually, the component most sensitive to inclement weather is the hit sensing system. This area should also be examined during testing.

The current 3-dimensional target body, when presented at the prescribed angle of 35-45 degrees, is subject to being hit twice as the projectile passes through. The current counting rate is one hit per 12 miliseconds, which should preclude the scoring of double penetrations. At the same time, it should permit individual scoring of multiple hits from a single burst of automatic fire. A firing rate of 10 rounds per second (600 rounds per minute) allows 100 milliseconds between rounds. However, testing should be conducted during the acceptance period to identify any problems in this area.

<u>Sound Simulator Subsystem</u>. The function of small arms sound simulators on a training facility is to add to the realism of the training situation by providing realistic audio cues as aids to the trainee in localizing enemy firing positions. The IRETS specification[21] calls for two sound simulators on each firing lane of the IRETS range. These simulators are to be located within 30 meters of selected targets. It is unlikely that two simulators will be adequate to represent the audio cues for 15 targets spread over an area 30 by 300 meters. Serious consideration should be given to increasing the number of sound simulators and locating these at specific target locations.

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20 Department of the Army, July 1977. <u>ibid</u>.

21 Department of the Army, July 1977, <u>ibid</u>.

The contractor for the IRETS is currently testing two types of sound simulators: an oxygen-propane (OP) system and a sound amplifying (SA) system. Initial tests of the two systems have shown that the OP system produces a louder, more realistic noise than the SA system. The OP system, however, is more expensive than the SA system. For this reason it may be too costly to provide ten to fifteen such systems per lane of the IRETS. Consideration should, therefore, be given to a less costly system, even though it may be necessary to accept less realism under these conditions. One such system might consist of a collection of megaphone speakers located at each target, both moving and stationary. These would be connected via a switching mechanism to a single, large amplifier and signal generator. As a given target in the system is raised, a switch would turn on its co-located speaker. At this time, the small arms firing signal being generated at the system's source would be put out by the speaker. In this way a directional, audio cue would be provided each time a target was presented.

Data Collection and Target Interface. According to the IRETS specifications[22], the target controller and the data recording systems are not necessarily connected. The lack of such an interface could seriously reduce the IRETS's value as a training support system. For example, future research may indicate that a more fluid or dynamic scenario would improve trainee performance. To achieve this capability, the control system would have to respond to incoming target signals.

If a computer system is used to drive the training facility and collect incoming data, it may be possible to use the computer's "decision-making" ability to vary target presentations as a function of the accuracy and volume of trainee fire. Sporadic and ineffective fire (as indicated by the number of hits) would cause the computer to increase the rate of advance of incoming targets. Conversely, accurate fire (many hits) could slow the rate of advance or even cause a simulated retreat. If this capability is inherent in the data collection and control hardware, it should be exploited.

Discussions with contractor personnel indicate that, although the computer handles both control and data collection functions, the "crossover" capability discussed above is not present in the current IRETS design. Further, it cannot and could not be introduced without major system changes. Thus, IRETS is limited to preprogrammed target scenarios and does not have a dynamic control capability as defined above.

Another problem in this area is the degree of flexibility in programming different scenarios. Ideally, range cadre should be able to develop different target presentation scenarios to simulate various combat actions (mass assault - all targets up; sniper action - brief repeated appearances of long range targets). The current software system does provide an

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22 Department of the Army, July 1977, ibid.

editor program which facilitates scenario preparation. Since the only output device is the console printer, positioning the line printer and typing in new instructions may not be an easy process for range control personnel who do not have some computer experience. The addition of a plug-in CRT display device, on which several lines of code can be displayed to the operator while he programs the scenario, would greatly facilitate the programming process.

The only output device, other than console display lights (which can show only one firing lane at a time), is the printer. Mechanical printing devices, similar to electric typewriters, are relatively fragile and are sensitive to the environment in which they operate. The range environment is in no way similar to that of an environmentally controlled computer facility. The printer is likely to be subject to extreme temperature changes, humidity variations, and dust and dirt. Since no back-up system is provided, lengthy down-times could occur after prolonged use if the printer breaks down. Therefore, a back-up printer, or at least a plug-in CRT, should be made available.

Hardware Add-On Capability. As currently configured, the IRETS is designed for use on one of several predetermined defense ranges. If it were desirable to add additional capabilities to one of these ranges, it would be desirable to add to the target control and data collection circuits. As an example of such a need, a simulated assault phase may be required to enhance the realism of a defense training facility. Discussions with the contractor indicated that two input-output channels are available with the current IRETS for the addition of range devices. Relatively major changes, however, would be required to add subsystems beyond those already on the facility. For example, the four 25-meter targets, which are commanded by a single line, could not be switched to individual control. Thus, it may be appropriate to consider designing future IRETS control systems so that additional subsystems may be added without creating the need for major system control changes.

IRETS Control Console Operation. The IRETS control console is complex and may require operator training and specific operator skills, especially in the automatic mode of operation, for diagnostic equipment testing and alibi firing. This potential problem area should be examined during the operational testing for the IRETS.

Malfunction Feedback Circuits. Discussions with contractor personnel left it unclear the degree of control in IRETS concerning malfunction feedback. A malfunctioning target mechanism has a direct feedback loop through which the problem causing a malfunction is relayed to the console. However, a malfunctioning target hit sensor has no such feedback loop. This could result in a target that is "dead" for some number of runs. Reliability of the hit sensing system will play an important role in determining the need for such a system. This problem should also be closely examined during the acceptance testing of IRETS.

POTENTIAL SOFTWARE SHORTCOMINGS

This section discusses potential software shortcomings and addresses the following areas:

- o Diagnostic Measures of Performance
- o Hit Recording Subsystem

Diagnostic Measures of Performance. As currently configured, the IRETS system has no time based MOPs such as time to first round, time to first hit, or time to shift targets. The lack of a time based MOP system limits the capability of the IRETS to provide diagnostic data concerning firer performance. Additionally, the IRETS has no miss-distance indicator. The lack of such an indicator makes it difficult to determine (in the case of moving targets) whether firers consistently lead or fire behind the targets. If such diagnostic aids could be added, the system's ability to train a firer to improve his firing technique would be significantly enhanced.

Talks with contractor personnel indicated that time based data could not be collected directly. Events could be measured or timed externally and the finished event occurrence could be fed into the IRETS. For example, a near miss indicator could measure, without aid from IRETS, whether near misses passed to the left or right of the target. After measurement, the number passed or the fact that a round passed to one side or the other could be fed into the system. Times to first hit could be handled in the same manner, measured externally, and then inserted into the IRETS computer. Thus, until the current IRETS is augmented with the above capabilities, it will have a limited flexibility in terms of providing time based diagnostic data.

Hit Recording Subsystem. The contractor for the IRETS is developing the hit recording system. If the developed system uses a computer to collect information concerning target hits and operating status, it is highly probable that all firing lanes will share the same input channel (bus bar). (It is common for various input-output equipment to share channels since, under computer control, they are not used simultaneously.) Hits, however, which are generated by the firers are not under computer control. If the various hit data links share a given input channel, there is the remote possibility of data loss, should two hit signals arrive within a given time period. Thus, the length of that time period is critical to the successful collection of hit data. For this reason, the length of this time period should be adjusted so that the probability of data loss is minimized. In this way, the likelihood of all data being recorded will be maximized. The examination of the hit recording system during operational testing should thus address this area in order to determine if a deficiency in this area exists.

SUMMARY AND RECOMMENDATIONS

In the previous section of this report, potential shortcomings in the IRETS with respect to its capability to provide for the conduct of rifle marksmanship training in a threat oriented context were identified and discussed. The purpose of this section of the report is to summarize the findings of the analysis of the IRETS and to present recommendations, as appropriate, for resolving the identified shortcomings.

IRETS REPRESENTATION OF THE THREAT

Analysis of the adequacy with which the IRETS portrays the rifle defeatable threat considered the following specific factors:

- Target separation on the IRETS range,
- Target-to-firer distances represented on the IRETS range,
- Target presentation frequency,
- Target exposure times,
- Employment of battlefield noises,
- Employment of limited visibility conditions.

In addition to the above factors, selected aspects of rifle marksmanship training were discussed with respect to the IRETS capabilities. These included:

- Firing positions appropriate for trainee use during live firing,
- Night training considerations,
- Squad member live firing interactions,
- Diagnostic data collection during live fire training.

For the above factors, analysis of the IRETS capabilities yielded the following findings and recommendations:

- Target spacing on the IRETS range is inadequate. The target separation distances planned for the IRETS are too large. It may be appropriate to consider adding additional targets or moving targets at selected ranges closer together so that the separations for collections of targets in the same range band are closer to the expected combat separations.

- The distribution of target engagements as a function of target-to-firer range planned for the IRETS is at variance with the distribution appropriate for representing the combat threat. For this reason, the IRETS scenario should be adjusted so that the frequency with which targets are presented within successive range bands parallels the frequency appropriate for combat targets.

- The question of the number of targets appropriate for representing a threat attack and a threat retreat has not been resolved. Military experts should consider this problem and decide what constitutes the appropriate number of target presentations for the IRETS defense scenario.

- Deviations were found to exist between the target exposure times planned for use in the IRETS defense scenario and those recommended for use in small arms training facilities. The deviations for target exposures found to be too short should be resolved as discussed in the findings section of the report. The deviations for target exposures found to be too long should also be resolved, if this can be accomplished without great difficulty.

- No provision has been made for the employment of battlefield noises during training on the IRETS system. The possibility of adding such noises to the IRETS should be investigated during the operational testing phase of the system.

- No provision has been made for training under limited daylight visibility conditions using the IRETS. The possibility of conducting training under these conditions with the system should also be investigated during the operational testing phase of the system.

- As currently planned, the IRETS is designed to allow trainees to fire from the foxhole and prone firing positions. This is consistent with the current U. S. Army doctrine concerning battlefield firing positions. It has been found, however, that the kneeling and standing firing positions are employed with a much greater frequency during combat than the foxhole and prone positions. These results suggest that some consideration should be given to providing firing positions on the IRETS range that will allow trainees to fire from the standing and kneeling positions.

- Past experience in night live fire exercises indicates that the proposed firing distances for the IRETS defense scenario are too long for adequately training soldiers in night firing techniques. This potential problem should be investigated during the operational testing of the system.

- The IRETS as currently configured does not permit an individual to train as a part of a fire team or other small unit. The possibility of using the portable IRETS for this purpose should be investigated during the operational testing of the system.

- The IRETS range data collection capabilities do not provide a means for collecting diagnostic measures of performance relative to the use of appropriate target lead, sighting technique, and firing technique. The augmentation of the system with a capability to measure these aspects of the trainee's firing performance should be investigated.

POTENTIAL HARDWARE AND SOFTWARE SHORTCOMINGS

Analysis of the hardware and software components of the IRETS with respect to its capability to provide for the conduct of threat oriented marksmanship training considered the following aspects of the system:

- Moving target subsystem,
- Hit sensing subsystem,
- Sound simulator subsystem,
- Data collection and target interface,
- Hardware add-on capability,
- IRETS control console operation,
- Malfunction feedback circuits,
- Diagnostic measures of performance,
- Hit recording subsystem.

For these aspects of the IRETS, analysis yielded the following findings and recommendations:

- The moving target "running distances" are too short to realistically represent the fire and movement tactics of threat personnel targets. Consideration should be given to lengthening the target track or reducing target speeds so that longer moving target exposures can be achieved.

- The data/control cable that trails behind the moving target platform may be subject to abrasion, severing, and cracking.

This potential difficulty should be assessed during acceptance and/or operational testing for the system.

- There may be problems in keeping the moving targets operational due to the use of a chain drive to move these targets. This potential difficulty should also be assessed during the IRETS testing.

- The hit sensing subsystem may fail to record hits achieved on the upper part of the moving target body. The extent to which this is likely to occur should be investigated during the testing for the system.

- After a rain storm, it is to be expected that a certain period of time will be required for the IRETS to dry out before it can be used again for live fire exercises. This time should be relatively short in order to avoid excessive down time during scheduled training activities. The extent to which system dry out time may be excessive should be determined. In the case that this time is judged to be excessive, measures should be developed to reduce the dry out time.

- When a given rifle projectile passes through the curved portion of the target body, the specifications call for a single hit being scored. It is possible that a multiple hit might be scored in some cases. The extent to which this occurs during live firing with the IRETS should be investigated during operational testing of the system.

- The hit sensing subsystem of the IRETS should be able to score multiple hits when live firing is conducted in the automatic mode. The extent to which the IRETS has this capability should be addressed during operational testing.

- The sound simulators currently planned for the IRETS are not co-located with the targets on the IRETS range. Further, too few simulators are planned for the IRETS range. Consideration should be given to increasing the number of sound simulators and co-locating a simulator with each target on the range.

- The data collection and target control components of the IRETS are not interconnected. For this reason, the IRETS has no capability for making a "dynamic" response to the level of fire generated by the trainee. The possibility of redesigning the IRETS for this capability should be investigated.

- Programming new scenarios into the IRETS by range personnel may prove to be difficult, particularly for personnel with limited experience in computer programming. The addition of a CRT

device to assist these personnel in reprogramming should be investigated.

- There is no back-up printer for the IRETS system. Since the printer is mechanical and likely to be subject to excessive failures in a range environment, the possibility of augmenting the IRETS with a back-up printer should be investigated.

- There may be insufficient input-output channels for future expansions of the system. This potential problem area should be considered and its likely consequences for future applications of the system should be determined.

- The operation of the IRETS control console by range personnel may require special training. Possibly, personnel with special knowledge and skills will be required to operate this equipment. These possibilities should be investigated during operational testing of the system.

- As currently designed, the IRETS has no malfunction feedback circuit for the hit sensing subsystem. Because of this, failures in this subsystem may remain undetected until several uses of the system have been completed during a given training period. As a consequence, the need for a malfunction circuit should be investigated during operational testing.

- As it now exists, the IRETS has no capability to provide time based measures of firing performance. This limits the diagnostic capabilities of the system. The possibility of augmenting the system with the capability for providing such measures should be investigated. In this way, the system's ability to train a firer to improve his firing technique would be significantly enhanced.

- If the various hit data links share a common input channel to the hit recording subsystem, it is possible that some loss of data will occur should two or more hit signals arrive simultaneously at the recording subsystem. Therefore, tests should be conducted to determine to what extent data are lost, if at all, during the operation of the system over a number of training periods.

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